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CLAIMS

1. Polycrystalline gallium nitride (GaN), wherein the atomic fraction of gallium ranges from between about 49% to 55%, and having an apparent density of between about 5.5 and 6.1 g/cm^3, and a Vickers hardness of above about 1 GPa.

2. The GaN of claim 1, which has a thickness or minimum dimension of between about 0.2 mm and 1 m.

3. The GaN of claim 1, which has a diameter or maximum dimension of between about 1 mm and 1 m.

4. The GaN of claim 1, which has equiaxed grains with an average size of between about 0.01 and 50 μm.

5. The GaN of claim 1, having surfaces that are substantially smooth, with a root-mean-square roughness below about 100 μm.

6. The GaN of claim 5, having surfaces that are substantially smooth, with a root-mean-square roughness below about 20 μm.

7. A method for making sintered polycrystalline gallium nitride (GaN), which comprises the steps of:
   (a) enclosing and sealing GaN as one or more of powder or a cold-pressed pill, in a non-metallic container;
   (b) subjecting said container to hot isostatic pressing (HIPing) at a temperature ranging from about 1150° C to 1300° C and a pressure ranging from between about 1 and 10 Kbar; and
   (c) recovering polycrystalline GaN from said container.

8. The method of claim 7, wherein said non-metallic container is evacuated of air prior to sealing.

9. The method of claim 7, wherein said HIPing is conducted for a time ranging from about 2 minutes to about 24 hours.

10. The method of claim 7, wherein said recovering step includes grinding off the container from said sintered polycrystalline GaN.

11. The method of claim 7, wherein said sintered polycrystalline GaN has a thickness or minimum dimension of between about 0.2 mm and 1 m.

12. The method of claim 7, wherein said sintered polycrystalline GaN has a diameter or maximum dimension of between about 1 mm and 1 m.

13. The method of claim 7, wherein said sintered polycrystalline GaN has equiaxed grains with an average size of between about 0.01 and 50 μm.

14. The method of claim 7, wherein said sintered polycrystalline GaN has surfaces, which are substantially smooth, with a root-mean-square roughness below about 100 μm.

15. The method of claim 14, wherein said sintered polycrystalline GaN has surfaces, which are substantially smooth, with a root-mean-square roughness below about 20 μm.

16. The method of claim 7, wherein said GaN enclosed in said container is a powder.

17. The method of claim 7, wherein said GaN enclosed in said container is a cold-pressed pill.

18. A method for making sintered polycrystalline gallium nitride (GaN), which comprises the steps of:

(a) placing GaN as one or more of powder or a cold-pressed pill in a high pressure/high temperature (HP/HT) reaction cell;

(b) placing said reaction cell in a HP/HT apparatus;

(c) subjecting said container to a temperature ranging from about 1200° to 1800° C and a pressure ranging from about 5 to 80 Kbar; and

(d) recovering polycrystalline GaN from said reaction cell.

19. The method of claim 18, wherein step (c) is conducted for a time ranging from about 2 minutes to about 24 hours.

20. The method of claim 18, wherein said recovering step includes grinding.

21. The method of claim 18, wherein said sintered polycrystalline GaN has a thickness or minimum dimension of between about 0.2 mm and 1 m.

22. The method of claim 18, wherein said sintered polycrystalline GaN has a diameter or maximum dimension of between about 1 mm and 1 m.

23. The method of claim 18, wherein said sintered polycrystalline GaN has equiaxed grains with an average size of between about 0.01 and 50 μm.

24. The method of claim 18, wherein said sintered polycrystalline GaN has surfaces, which are substantially smooth, with a root-mean-square roughness below about 100 μm.

25. The method of claim 24, wherein said sintered polycrystalline GaN has surfaces that are substantially smooth, with a root-mean-square roughness below about 20 μm.

26. The method of claim 18, wherein said GaN enclosed in said container is a powder.

27. The method of claim 18, wherein said GaN enclosed in said container is a cold-pressed pill.